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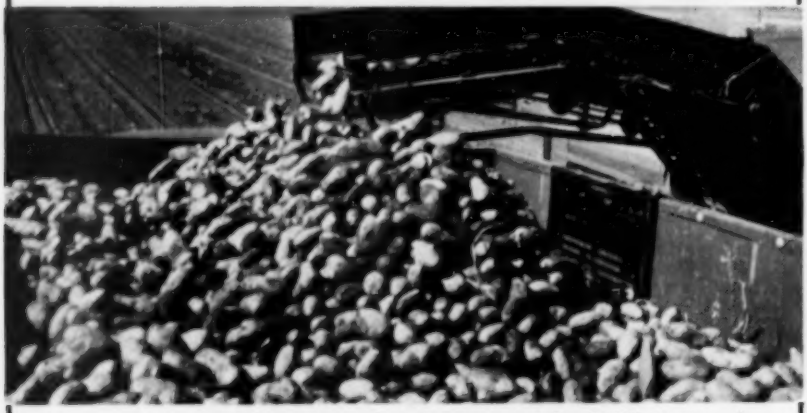

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OUR COVER PICTURE—*A typical track-side potato storage in Aroostook County, Maine. Farmers and dealers store their potatoes in bulk in these storages for easy and safe winter shipment. Photo courtesy Horticultural Crops Research Branch, USDA.*

EARLY GEM: A NEW EARLY, RUSSET-SKIN, SCAB-RESISTANT VARIETY OF POTATO ADAPTED TO THE EARLY POTATO-PRODUCING SECTIONS OF IDAHO AND TO CERTAIN SECTIONS OF NORTH DAKOTA[1]

F. J. Stevenson,[1] John G. McLean,[1] W. G. Hoyman,[1] and R. V. Akeley[1]

On April 24, 1953, the United States Department of Agriculture and the Idaho and North Dakota Agricultural Experiment Stations released a new variety of potato named Early Gem.

Early Gem was tested under the pedigree No. B 515-2 of the United States Department of Agriculture. It is a selection from the cross Russet Burbank and X 96-56. The female parent, Russet Burbank, also known as Netted Gem, Golden Russet, Idaho Russet, Klamath Russet, and California Russet, is grown in at least 14 states. Russet Burbank produces long russet-skin tubers. It is late maturing; and is resistant to scab but susceptible to all other major diseases of potatoes. It is much in demand as a baker when grown in Idaho and other states of the Northwest. The pollen parent, X 96-56, produces oblong white-skin tubers. The parent is early maturing, highly resistant to, if not immune from, the common race of the late blight fungus, resistant to mild mosaic, and moderately resistant to common scab.

The cross was made and the seedlings were grown first in the greenhouse of the Plant Industry Station, Beltsville, Maryland, in 1943. Tubers of the progeny were sent to Maine for increase. B 515-2 was selected on the Chapman Farm, Maine, in the fall of 1944. It was given preliminary tests but did not appear promising in that state. It was continued in the tests because its tubers resembled those of Russet Burbank. Tests in various states indicate that it is not widely adapted, but it is promising in the early potato-growing section of Idaho and in sections of North Dakota where the soil is not too heavy.

The pedigree of Early Gem (B 515-2) follows:

Early Gem (U.S.D.A. Seedling No. B 515-2)
- X 96-56
  - Earlaine
  - U.S.D.A. 3895-13
- Russet Burbank

[1] Accepted for publication July 26, 1954.

Principal Geneticist (Beltsville, Maryland), Senior Horticulturist (Idaho Branch Experiment Station, Aberdeen, Idaho), Agent (Plant Pathologist) (North Dakota Agricultural Experiment Station, Fargo, N. Dak.), and Senior Horticulturist (Presque Isle, Maine), respectively, Horticultural Crops Research Branch, Agricultural Research Service, United States Department of Agriculture.

Description

PLANTS.—Medium to small; spreading. *Stems*: *Medium thick*, prominently angled. *Nodes*: Slightly swollen, green. *Internodes*: Green. *Wings*: Prominent, waved, single, green. *Stipules*: Of leaves—Medium-sized, green, scantily pubescent. *Leaves*: Medium-sized, closed, green. *Midribs*: Green, scantily pubescent. *Petioles*: Green, scantily pubescent. *Terminal leaflets*: Medium-sized, elliptical-ovate, acute, symmetrical. *Primary leaflets*: Medium-sized, elliptical-ovate, four pairs, mean length 48.9 ± 0.7 mm. (1.9 inches),[2] mean width 32.9 ± 0.5 mm. (1.3 inches), index 67.6 ± 0.7. *Petiolules*: Green. *Secondary leaflets*: Many, between pairs of primary leaflets and at junction of midrib and petioles. *Tertiary leaflets*: Few. *Inflorescence*: Medium-branched. *Leafy bracts*: None. *Peduncles*: In axils of petioles and main stem, medium in length, green, scantily pubescent. *Pedicels*: Long to medium in length, green, scantily pubescent.

FLOWERS.—*Buds*: Green, calyx lobes long (8-10 mm.), awl-shaped, not foliaceous, straight and green tips. *Corolla*: Medium-sized (25-31 mm.), white. *Anthers*: Orange-yellow. *Pollen*: Abundant, good quality. *Style*: Straight. *Stigma*: Flattened globose, multilobed, green.

TUBERS.—Medium long to long, elliptical, medium thick, mean length 91.2 ± 0.5 mm. (3.6 inches),[3] mean width 71.9 ± 0.4 (2.8 inches),[3] mean thickness 59.3 ± 0.4 mm. (2.3 inches);[3] indexes, width to length 79.1 ± 0.4,[4] thickness to length 65.3 ± 0.6,[5] thickness to length 82.6 ± 0.5.[5] *Skin*: Smooth, light to medium heavy, russet. *Eyes*: Shallow, same color as skin. *Eyebrows*: Medium long, curved, prominent. *Flesh*: White. *Sprouts*: Color when developed in dark, vinaceous-lilac (Ridgway).[6] *Maturity*: Very early.

Early Gem in Idaho

Characteristics. Early Gem, although an early variety, has been grown in Idaho under conditions favoring the late-maturing Russet Burbank; consequently, the tubers of Early Gem often develop an excessive amount of growth cracking, a characteristic inherited, together with russet skin, from the parent, Russet Burbank.

Early Gem sets fewer tubers per plant than Russet Burbank during a shorter period. As a result, fewer undersize tubers and a greater

[2]Calculated by dividing the width by the length of each 100 leaflets and multiplying the average of these ratios by 100. The leaflets were taken from the fourth leaf from the top of the stem, one leaflet the distal left lateral being taken from each leaf. Since the potato leaflet is asymmetrical, the length was determined by taking the average of the measurements from the apex to the base of each respective lobe.

[3]The average measurements of 100 tubers, each of a weight of approximately 8 ± 1 ounces.

[4]Calculated by dividing the width of each 100 tubers by the length and multiplying the average of these ratios by 100. The data used for calculating the indexes were taken from the same measurements as those used to determine the dimension of the tubers.

[5]Based on measurements of the same tubers as those used for determining the width-to-length index and on same methods of calculation.

[6]Ridgway, R. 1912. Color standard and color nomenclature. (43 Pp.), illus. Washington, D. C.

percentage of No. 1's are produced by Early Gem than by Russet Burbank provided growth cracks are not allowed to develop. Early Gem was tested for yield and percentage solids in comparison with Russet Burbank for 3 years at Parma, Lewiston, and Aberdeen, Idaho. The 3-year means show that Early Gem yielded more U. S. No. 1 potatoes than Russet Burbank at Parma and Aberdeen, but that the reverse was true at Lewiston (Table 1). Early Gem was lower than Russet Burbank in percentage solids at all 3 locations (Table 1).

The comparative tests at Parma are the most important, since this location is in the early potato section of Idaho and Early Gem was released to meet a need in that section. Russet Burbank, Triumph, and White Rose are the varieties commonly grown there. Early Gem was tested in comparison with these 3 varieties at Parma for 3 years. A comparison of the 3-year means of U. S. No. 1 potatoes in the tests there shows the varieties to rank in the following order: White Rose, Triumph, Early Gem, and Russet Burbank, with 314, 230, 225, and 205 bushels per acre, respectively. Russet Burbank ranked first in solids with 22.4 per cent, Triumph second with 20.7, and Early Gem third with 20.4. In 1953, the only year in which solids of White Rose were calculated, the four varieties ranked in the following order: White Rose 25.5 per cent; Russet Burbank, 25.2; Early Gem, 21.9; and Triumph 21.6.

In the production of U. S. No. 1 potatoes, Early Gem was outyielded by White Rose but compared favorably with Russet Burbank and Triumph. Early Gem was not so high in percentage of solids as Russet Burbank but was about the same as Triumph. However, both Early Gem and Triumph were high enough in percentage solids on the average at Parma so that they could be classified as bakers. The present more or less arbitrary requirement for a baker is 19.7 per cent solids, or 1.080 specific gravity. The 3-year average in the Parma tests was 20.4 per cent solids for Early Gem and 20.7 for Triumph.

Cultural Requirements. Growth cracking is the major defect of the Early Gem variety and under adverse conditions it could result in the loss of 50 to 65 per cent of the crop. However, Early Gem, an early variety, has been grown in the trials with the same cultural practices of spacing, irrigating, fertilizing, and cultivating as used in growing late varieties. These measures are thought to favor the production of growth-cracked tubers, which are responsible for most of the differences between total yield and yield of U. S. No. 1 potatoes of Early Gem shown in table 1.

In Idaho intensive trials are under way to determine the best methods for growing Early Gem under irrigation. W. C. Sparks, Associate Horticulturist, at Aberdeen, summarized the results on spacing as follows: "The results of a single season indicate that close spacing within the row —6 to 9 inches as compared with 12 inches— increases total yield and yield of U. S. No. 1 tubers, and decreases the amount of growth cracking, regardless of whether the space between the rows is 32 or 36 inches."

From results of tests for 1 year, G. L. Corey, Irrigation Engineer, Aberdeen, Idaho, reports: "The Early Gem is not so adversely affected by insufficient irrigation as the Russet Burbank. For optimum yield Early Gem should be irrigated frequently and lightly, especially during hot weather. Frequent irrigations tend to reduce growth cracks. Heavy

TABLE 1.—*Total yield, yield of U. S. No. 1 potatoes, and percentage solids of Early Gem compared with those of Russet Burbank, Triumph, and White Rose in a number of tests in Idaho, 1951 to 1953.*

Variety	Year	Parma			Lewiston			Aberdeen			Mean Yield	
		Total Yield	U.S. No. 1 Yield	Solids	Total Yield	U.S. No. 1 Yield	Solids	Total Yield	U.S. No. 1 Yield	Solids	U.S. No. 1	Mean Solids
		Bus.	Bus.	Per cent	Bus.	Bus.	Per cent	Bus.	Bus.	Per cent	Bus.	Per cent
Early Gem												
	1951	296	265	20.4	319	211	18.6	427	256	16.3	244	18.4
	1952	265	85	19.0	342	306	19.9	279	205	17.4	199	18.8
	1953	398	325	21.9	460	347	21.5	405	240	18.6	304	20.7
	Mean	320	225	20.4	374	288	20.0	370	234	17.4	249	19.3
Russet Burbank												
	1951	283	127[1]	21.6	392[2]	270	.....	386	154[1]	19.5[2]	184	20.6
	1952	370[2]	115	20.4	491[2]	427	22.7[2]	324[2]	209	19.9[2]	250	21.0
	1953	522[2]	373	25.2[2]	682[2]	488	20.4	467[2]	238	23.0[2]	366	22.9
	Mean	392	205	22.4	522	395	21.6	392	200	20.8	267	21.6
Triumph												
	1951	301	290	20.4	305	275	19.3	.....	.....	.....	188	19.9
	1952	245[1]	126	20.1	428	315	22.7[2]	.....	.....	.....	220	21.4
	1953	349[1]	273[1]	21.6	433	228	20.9	303[1]	188[1]	18.1	230	20.2
	Mean	298	230	20.7	389	273	21.0	.....	.....	.....	252	20.9
White Rose												
	1951	386[2]	230	.....	413[2]	286[2]	.....	479	158[1]	.....	225	.....
	1952	471[2]	134[2]	.....	710[2]	637[2]	23.2	417[2]	292[2]	.....	354	.....
	1953	743[2]	578[2]	25.5[2]	913[2]	737[2]	23.0[2]	517[2]	305[2]	19.4	540	22.6
	Mean	533	314	.....	679	553	23.1	471	252	.....	373	.....

[1]Significantly lower than Early Gem in the same year and at the same location.
[2]Significantly higher than Early Gem in the same year and at the same location.

applications of nitrogen greatly increase the amount of growth cracking, therefore care should be taken to use no more than a minimum of nitrogen. Moderate amounts of phosphate proved as beneficial as heavy rates. No response to potash was found at Aberdeen."

Adaptation. Early Gem, although a russet-skin variety, will probably not compete with the late-crop Russet Burbank in eastern Idaho. However, it shows promise as an early-crop potato in western Idaho, where it can be marketed at a time when the Russet Burbank is still immature and of inferior quality. It may also provide, to a limited extent, a late-August or early-September market potato in the later growing area of eastern Idaho.

In 1952, and again in 1953, on dry land at the station at Tetonia, Idaho, under conditions of insufficient moisture, Early Gem outyielded Russet Burbank by as much as 100 per cent and produced many more tubers over 2 inches in diameter. This was not true in 1951 when rains occurred during the growing season.

EARLY GEM IN NORTH DAKOTA

The behavior of Early Gem in North Dakota has been described in an article by Hoyman, *et al.*[7] However, for the benefit of some readers

of the *American Potato Journal*, who do not have access to that article, and for the completeness of this paper, the important features of the North Dakota article with certain modifications will be repeated here.

In 1947, seedling variety B 515-2, now known as Early Gem, was selected in the experimental plots on the Chapman Farm, Maine, by Dr. Hoyman as a variety that might be worth testing in North Dakota. In 1948 it was planted at Grand Forks, North Dakota, and at harvest time it appeared to be the best of many russet-skin seedlings. The following year at Northwood it continued to show promise.

In 1950 a few pounds of seed potatoes of Early Gem were given to each of a few growers, and in 1951 the increase at Northwood, North Dakota, was equally distributed to more growers. The favorable reports received from potato growers were largely responsible for the decision to release the variety.

Early Gem was tested in two or more replicated yield trials by the Department of Horticulture of the North Dakota Agricultural Experiment Station for four years, 1950 to 1953, in comparison with the standard varieties Irish Cobbler, Triumph, and Red Pontiac.[7] Comparable statistics on total yield, percentage U. S. No. 1 tubers, and percentage solids are given in table 2.

TABLE 2.—*Total yield, percentage U. S. No. 1 potatoes, and percentage solids of Early Gem grown in comparison with three standard varieties in North Dakota, 1950-1953.*

Variety	Year	Total Yield	U.S. No. 1 Tubers	Solids
		Bus.	Per cent	Per cent
Early Gem	1950[1]	232	....	20.4
Irish Cobbler	1950	242	....	22.9
Triumph	1950	221	....	21.4
Red Pontiac	1950	288	....	20.4
Early Gem	1951[2]	253	79	17.3
Irish Cobbler	1951	277	91	19.7
Triumph	1951	323	93	17.7
Red Pontiac	1951	375	93	17.3
Early Gem	1952[2]	273	86	19.1
Irish Cobbler	1952	293	94	21.4
Triumph	1952	282	94	19.7
Red Pontiac	1952	354	97	19.1
Early Gem	1953[3]	315	94	19.2
Irish Cobbler	1953	329	93	21.4
Triumph	1953	312	93	19.9
Red Pontiac	1953	363	93	19.2

[1]Trials at Grand Forks and Langdon.

[2]Trials at Grand Forks, Fargo, Langdon, and Minot, and with and without irrigation at Williston, North Dakota.

[3]Trials at Grand Forks, and Langdon, North Dakota, and with and without irrigation at Williston.

[7]Hoyman, William G., Shultz, J. H., and Johansen, Robert. 1954. Early Gem, A New Russet-Skin Potato. N. Dak. Bimonth. Bull. 16:(3) 88-92.

Early Gem was comparable in total yield with the early varieties Irish Cobbler and Triumph except that Triumph outyielded Early Gem significantly in 1951. Red Pontiac, a late variety, usually produces higher yields than the early varieties.

Early Gem and Triumph were compared for total yield, percentage U. S. No. 1 potatoes, and percentage solids when grown on soils of different types and textures. Data taken from replicated yield trials grown in 1952 are given in table 3.

The total yield of Early Gem, as indicated in table 3, may vary greatly depending on the environment. All the trials have indicated that Early Gem is a potentially high-yielding variety under ideal growing conditions. The data on percentage of U. S. No. 1 potatoes are in conformity with observations in other trials: namely, on the sandy more loamy soils, Early Gem may grade a high percentage of U. S. No. 1's whereas on the heavy clay soils such as Fargo clay the percentage of U. S. No. 1's may be low because of an excessive amount of growth cracks. Under comparable conditions Triumph produced a high percentage of U. S. No. 1 potatoes. It is concluded that Early Gem should not be grown in heavy clay soils in North Dakota except under unusual circumstances.

TABLE 3.—*Total yield, percentage U. S. No. 1 tubers, and percentage solids of Early Gem and Triumph varieties of potato on different soil types in 1952.*

Location in North Dakota	Soil Type	Early Gem			Triumph		
		Total Yield	U.S. No. 1 Tubers	Solids	Total Yield	U.S. No. 1 Tubers	Solids
		Bus.	Per cent	Per cent	Bus.	Per cent	Per cent
Fargo	Fargo clay	409	57	18.4	329	96	19.2
Grand Forks	Bearden clay loam	217	90	18.4	243	96	18.4
Langdon	Barnes loam	148	93	18.9	188	92	21.0
Minot	Williams silt loam	231	83	18.7	256	89	19.2
Williston (Dryland)	Williston sandy loam	253	98	19.1	285	97	19.7
Williston (Irrigated)	Havre silty clay loam	380	98	21.0	392	93	20.5

The percentage solids based on specific gravity of Early Gem potatoes grown on dryland in North Dakota is about equal to that of Red Pontiac but not quite so high as that of Triumph and considerably below that of Irish Cobbler (Table 2). However, when grown under irrigation at Williston, North Dakota, the dry-matter content of Early Gem was higher than that of the tubers of Pontiac.

When the first specific-gravity readings of Early Gem were found to be comparatively low there was some concern as to the acceptance of this potato for the table. However, specific gravity is only one criterion

of the eating value of potatoes. During the four years Early Gem was increased by growers in North Dakota, many favorable reports were received from farmers and others regarding its table quality. Various types of cooking tests indicated that it is very similar in cooking quality to Triumph and Red Pontiac, two standard varieties in the state. Early Gem grown in North Dakota is not as mealy when baked as Russet Burbank grown in Idaho, but when both were grown in North Dakota Early Gem appeared mealier.

General Characteristics

Early Gem is classified as a very early variety. In North Dakota it matures in approximately the same growing season as Irish Cobbler.

It is a russet-skin variety. However, the russeting varies from light to medium heavy depending on soil conditions. The tubers of Early Gem are medium long to long. They are usually not so long as those of the Russet Burbank parent. The tubers of Early Gem have a long rest period, and as a result, they keep well in storage. However, if they are held at a low temperature they accumulate sugars, and they recondition very slowly when changed to higher temperatures so that they may not be very suitable for chipping.

Early Gem has been tested for scab resistance in a number of states. It is not immune from but highly resistant to scab. It may be resistant to the virus that incites purple top wilt. In 1953 in North Dakota 1 per cent purple top was the highest recorded in any field of Early Gem, but as high as 20 per cent was found in fields of Red Pontiac. Early Gem is apparently susceptible to all other major diseases that attack potatoes. In this respect it resembles its parent, Russet Burbank.

Discussion and Summary

Early Gem, a new, russet-skin scab-resistant early maturing variety of potato shows promise in the early potato-producing section of Idaho and in the lighter loamy soils of North Dakota. Its tendency to develop growth cracks either with abundant rainfall or under heavy irrigation toward the end of the growing season is its worst disadvantage. Growth cracks can be held to a minimum by withholding irrigation water or possibly by killing the tops if the moisture supply cannot be controlled. Early Gem is highly resistant to the common scab organism and may have some resistance to the virus causing purple top wilt, but insofar as is known at present it is susceptible to all other major diseases affecting potatoes.

It is comparable in yield with other early varieties such as Irish Cobbler and Triumph but not to such late varieties as White Rose and Red Pontiac.

Early Gem is not widely adapted. It was released to fill a need for a long russet-skin tuber that will mature early in western Idaho and that can be marketed at a time when the Russet Burbank is still immature and of inferior quality. It may also provide to a limited extent for a late-August or early-September market potato in the later-gowing area of eastern Idaho.

Early Gem can be used in most scab-infested soils, if they are properly drained and are not too heavy in texture.

POTATO WILDINGS IN CANADA[1]

N. S. WRIGHT[2] AND D. B. ROBINSON[3]

Potato wildings are somatic variations of the potato plant that are remarkably similar regardless of variety or geographic location. In field plantings wildings tend to have darker green, smoother foliage and to mature earlier than normal plants of the same variety. Wildings have few if any flowers, shorter and more numerous stems and hence a more bushy growth habit than normal (Figures 1 and 2). Both primary and secondary lateral leaflets are reduced in size and number, but terminal leaflets are enlarged and obvious (Figures 3 and 4). Tubers of wildings are small and numerous (Figures 5 and 6).

GEOGRAPHIC DISTRIBUTION

Although it is probable that wildings occur more frequently and more extensively than the literature would indicate, they have been reported previously only from the British Isles and Western Europe where they were first recognized about 1920 (1, 4). Recently wildings were identified in Canada in the provinces of Prince Edward Island and British Columbia where, for several years, they have been considered manifestations of the witches' broom virus disease. To date in Canada wildings have been found in the Irish Cobbler, Sebago, Green Mountain, Warba and White Rose varieties.

ECONOMIC IMPORTANCE

Wildings produce about three times as many tubers as normal potato plants but wilding tubers rarely exceed three ounces in weight and hence are of little or no commercial value. Because of the large number of tubers produced by wildings, the selection of small potatoes for seed may cause the number of wildings in a stock to increase very rapidly, and there have been instances where crops planted with non-certified small potatoes have been almost 100 per cent wildings. The marketable yield of such crops is negligible.

The elimination of wildings from a stock may be accomplished by roguing during the growing season or by the sole use of large tubers for seed.

DISTINCTION BETWEEN WILDINGS AND WITCHES' BROOM

As noted above, potato wildings in Canada have previously been considered manifestations of the witches' broom virus disease. In fact this conclusion was drawn by Murphy and McKay (3) in 1932 but was

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Contribution No. 1416 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.
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FIGURE 1.

FIGURES 1 AND 2.—Field appearance of potato wilding in variety Green Mountain (Figure 1) compared with normal plant of same variety (Figure 2).

FIGURE 2.—Normal Green Mountain.

FIGURES 3 AND 4.—Detached stem from White Rose wilding (Figure 3) above, showing simplified leaves and prominent terminal leaflets in contrast to normal White Rose foliage (Figure 4).

later refuted by McIntosh (2). Todd (4) explained that the material sent from Scotland to Murphy and McKay for study was evidently infected by the witches' broom virus. In common with plants affected by witches' broom, wildings have simplified leaves and an increased number of stems and tubers. Plants infected with witches' broom, however, lack the prominent terminal leaflets of wildings and, in advanced stages of infection, have a great many more stems and tubers than wildings (5). Both conditions are perpetuated by tubers but only the virus disease is transmissible by grafting.

FIGURE 4.—Normal White Rose foliage.

In addition to the gross morphological features that distinguish wildings, it has been found that the parenchyma cells of the internodal region of wildings are significantly larger than the corresponding cells of either healthy plants or those infected with witches' broom. This feature, which is visible with the aid of a hand lens (Figure 7), may be used to verify a diagnosis of wilding and to distinguish wildings from plants infected with witches' broom.

FIGURES 5 AND 6.—Root system of White Rose wilding (Figure 5) showing numerous small tubers in contrast to number of tubers produced by normal White Rose plant (Figure 6).

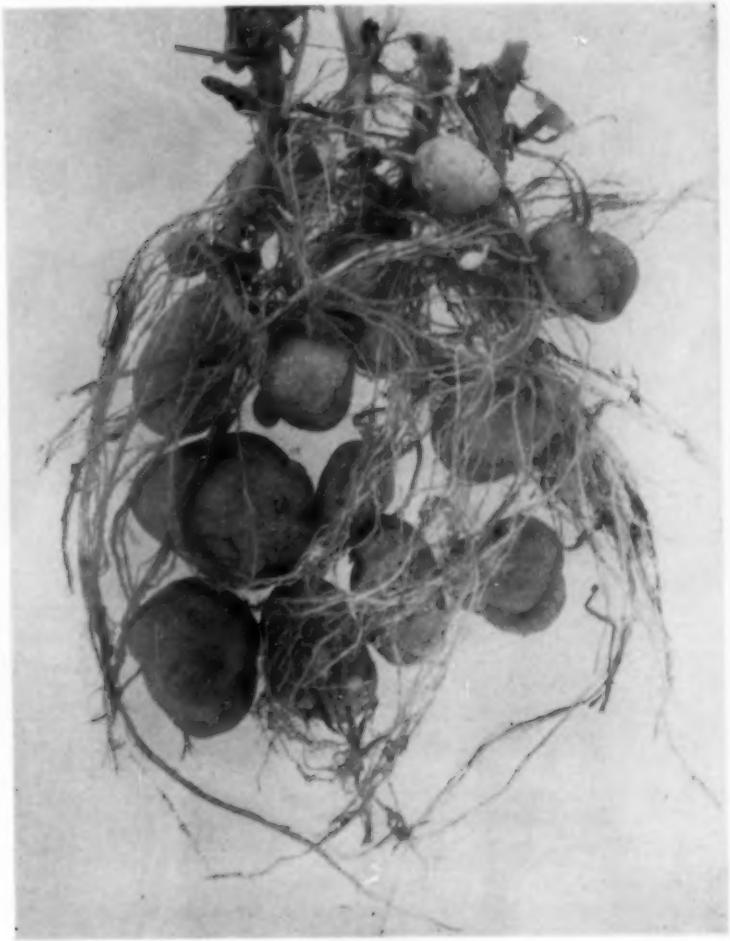

FIGURE 6.—Normal White Rose tubers.

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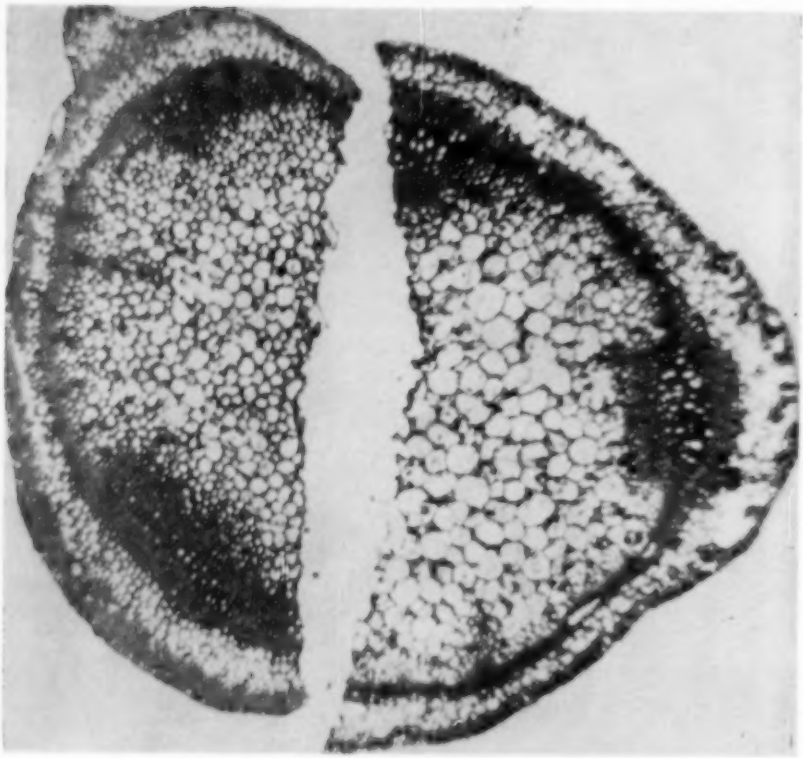


FIGURE 7.—Cross section of potato stems showing the enlargement of parenchyma cells in wilding plant (right) compared with normal plant (left). Magnification : 15x.

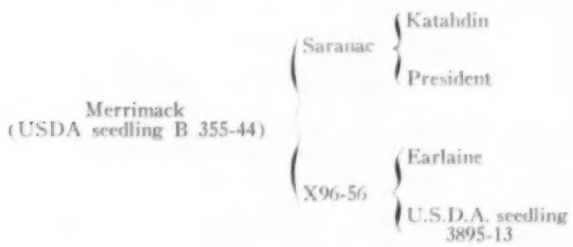
MERRIMACK:[1] A NEW VARIETY OF POTATO RESISTANT TO LATE BLIGHT AND RING ROT AND ADAPTED TO NEW HAMPSHIRE

R. V. AKELEY[2], F. J. STEVENSON[2], P. T. BLOOD[3], E. S. SCHULTZ[2], REINER BONDE[4], AND K. F. NIELSEN[4]

The Horticultural Crops Research Branch of the United States Department of Agriculture and the Agricultural Experiment Station of the University of New Hampshire have released a new variety of potato, Merrimack, bred by the United States Department of Agriculture and tested jointly by the two agencies.

Merrimac was tested under the pedigree number B 355-44. It is a selection from a cross of U.S.D.A. seedling No. X 96-56 and Saranac. X 96-56 is an early variety immune from the common race of the late blight fungus. Saranac is intermediate in resistance to the late blight fungus and highly resistant to ring rot. The cross was made and the progeny were first grown in a greenhouse at the Plant Industry Station, Beltsville, Maryland, in 1942. In 1943 the seedlings were grown in Maine, and in the years following they were tested for resistance to late blight and ring rot. B 355-44 was found to be immune from the common race of the late blight fungus and highly resistant to ring rot. Because of its disease resistance and its high market quality Merrimack was increased and given more extensive tests in Maine and at other State agricultural experiment stations as part of the National Potato Breeding Program.

The pedigree of Merrimack follows:



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[1] Accepted for publication July 30, 1954.
Merrimack, a river in New Hampshire.

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[4] Plant Pathologist and Assistant Agronomist, Agricultural Experiment Station of the University of Maine (Orono, Maine), respectively.

Description

PLANTS.—Large spreading. *Stems*: Medium in thickness, prominently angled. *Nodes*: Slightly swollen, green. *Internodes*: Slightly mottled. *Wings*: Prominent, medium waved, single, green. *Stipules*: of leaves — medium in size, green, scantily pubescent; of lowest peduncle small, scimitar-shaped, clasping green, scantily pubescent. *Leaves*: Medium in size to large, closed, green. *Midribs*: Green and scantily pubescent. *Petioles*: Green, scantily pubescent. *Terminal leaflets*: Large, ovate, apex acute, lobed and symmetrical base. *Primary leaflets*: Large, ovate, 3 pairs, mean length 48.8 ± 0.6 mm (1.9 inches), mean width 31.3 ± 0.4 mm. (1.2 inches), index 64.0 ± 0.5.[5] *Petiolules*: Green, secondary leaflets many, at junction of midrib and petioles and on petioles. *Tertiary leaflets*: Medium in number. *Inflorescence*: Much branched. *Leafy bracts*: None. *Peduncles*: Inserted in axils and petioles and main stem, long, green, scantily pubescent. *Pedicels*: Long to medium, green, scantily pubescent.

FLOWERS.—*Buds*: Green. *Calyx lobes*: Long (8-10 mm.), awl-shaped, not foliaceous, tips straight and green, scantily pubescent. *Corolla*: Large (diam. 31-37 mm.), white. *Anthers*: Orange-yellow. *Pollen*: Abundant and of good quality. *Style*: Slightly twisted to straight. *Stigma*: Globose, multilobed, green.

TUBERS.—Short and roundish, medium thick, mean length 80.6 ± 0.5 mm. (3.2 inches),[6] mean width 80.1 ± 0.5 mm. (3.2 inches),[6] mean thickness 58.7± 0.3 mm. (2.3 inches),[6] indexes, width to length 99.7 ± 0.9,[7] thickness to length 73.0 ± 0.6,[8] thickness to width 73.4 ± 0.6.[8] *Skin*: Smooth to netted, self-colored, cream buff to chamois (Ridgway).[9] *Eyes*: Shallow, of same color as skin. *Eyebrows*: Medium long, curved, medium prominent. *Flesh*: White. *Sprouts*: Color when developed in the dark, pale vinaceous lilac (Ridgway).[9] *Maturity*: Late.

Characteristics

The Merrimack is a vigorous-growing variety of potato that, in New Hampshire, compares favorably with the standard varieties in yield but will not compete in Maine with Kennebec and other high-yielding sorts. It produces short, roundish, medium-thick tubers with shallow eyes. The tubers are cream-buff to chamois in color, classed as white in the commer-

[5]Calculated by dividing the width by the length of each 100 leaflets and multiplying by 100. The leaflets were taken from the fourth leaf from top of the stem, one leaflet, the distal left lateral, being taken from each leaf. Since the potato leaflet is asymmetrical, the length was determined by taking the average of the measurements from the apex to the base of each respective lobe.

[6]The average of measurements of 100 tubers, each of a weight of approximately 8 ± 1 ounces.

[7]Calculated by dividing the width of each 100 tubers by the length and multiplying the average of these ratios by 100. The data used for calculating the indexes were taken from the same measurements as those used to designate the dimensions of the tubers.

[8]Based on measurements of the same tubers as those used for determining the width-to-length index, using the same methods of calculations.

[9]Ridgway, R. 1912. Color standards and color nomenclature. (43 Pp.) (Illus.) Washington, D. C.

cial trade. Its market quality is unusually excellent. Its dry-matter content is relatively high, about equal to that of Green Mountain and other high-quality varieties. It ranks high in table quality when baked or made into chips or french fries.

Both vines and tubers of Merrimack are highly resistant to if not immune from the common race of the late blight fungus. This variety is apparently immune in the field from virus A. It is highly resistant to net necrosis incited by current-season infection by the leaf roll virus but, like its Saranac parent, its vines are very susceptible to leaf roll. It is highly resistant to ring rot. It is the first variety released that is highly resistant to both late blight and ring rot.

In New Hampshire in 3 tests it ranked second in yield in a group of 5 varieties. Kennebec was first with a mean yield for the 3 tests of 458 bushels U. S. No. 1 potatoes per acre; Merrimack second, with 383; Green Mountain third, with 370; Katahdin fourth, with 307; and Irish Cobbler last with 238 (Table 1). It is thus evident that Merrimack produces satisfactory yields in New Hampshire.

In 8 tests in Maine, 4 in 1951 and 4 in 1953, Merrimack was outyielded by Green Mountain, Kennebec, and Katahdin, as shown by the means for each of the 4 tests (Tables 2 and 3).

In the 3 tests in New Hampshire Merrimack with a mean of 20.1 per cent solids was about the same as Green Mountain with a mean of

TABLE 1.—*Yields per acre and percentages of solids of the Merrimack variety of potato tested in comparison with those of standard varieties in New Hampshire, 1951-1953.*

Location	Year	Variety	U.S. No. 1 Tubers	U.S. No. 2 Tubers	Total Marketable Tubers	Solids
			Bus.	Bus.	Bus.	Per cent
Durham	1951	Merrimack	543	25	568	19.4
		Kennebec	651	28	679	17.7
		Green Mountain	438	42	480	18.5
		Katahdin	492	36	528	16.0
		Irish Cobbler	372	107	479	17.5
Madbury	1952	Merrimack	381	13	394	20.2
		Kennebec	447	20	467	18.4
		Green Mountain	399	35	434	21.5
		Katahdin	287	17	304	17.3
		Irish Cobbler	229	41	270	18.2
Dover	1953	Merrimack	225	30	255	20.7
		Kennebec	275	53	328	19.9
		Green Mountain	272	44	316	20.7
		Katahdin	142	56	198	18.7
		Irish Cobbler	114	72	186	20.3
Mean		Merrimack	383	23	406	20.1
		Kennebec	458	34	492	18.7
		Green Mountain	370	40	410	20.2
		Katahdin	307	38	345	17.3
		Irish Cobbler	238	73	311	18.7

TABLE 2.—*Yields and percentages of solids of the Merrimack potato compared with those of standard varieties grown at 4 locations in Maine, 1951.*

Variety	Dover-Foxcraft		Exeter		Presque Isle		Sherman Mills		Means All Locations		
	[1] Total	Solids	[1] Total	Solids	Total	Solids	[1] Total	Solids	To-tal	2"-4" Size	Solids
	Bus.	Per cent	Bus.	Per cent	Bus.	Per cent	Bus.	Per cent	Bus.	Bus.	Per cent
Merrimack	256	18.7	452	20.4	536	20.9	461	18.4	426	373	19.7
Green Mountain	446	19.2	460	20.2	702	22.2	503	19.1	533	423[2]	20.2
Kennebec	466	17.3	628	18.4	707	19.9	698	18.4	625	543	18.5
Katahdin	468	17.7	373	17.3	638	19.7	477	16.9	489	422[2]	17.9

[1] *Verticillium* wilt was chiefly responsible for low yields at Dover-Foxcraft. The yields of the susceptible varieties Green Mountain and Katahdin were greatly reduced by late blight tuber rot at Exeter and Sherman Mills.

[2] Calculated yields, since these varieties were not graded becauuse of late blight tuber rot.

TABLE 3.—*Yields and percentage of solids of Merrimack compared with those of standard varieties grown at 4 locations in Maine, 1953.*

Variety	Houlton		Exeter		Presque Isle		Madawaska		Mean for All Locations		
	Total	Solids	Total	Solids	Total	Solids	Total	Solids	To-tal	Over 2"	Solids
	Bus.	Per cent	Bus.	Per cent	Bus.	Per cent	Bus.	Per cent	Bus.	Bus.	Per cent
Merrimack	274	19.0	431	21.7	475	21.7	459	20.2	411	399	20.7
Green Mountain	564	21.0	341	17.4	520	21.6	581	19.7	502	481	19.9
Kennebec	566	21.2	372	19.4	540	20.2	568	18.4	512	497	19.8
Katahdin	579	19.7	319	18.2	486	20.5	548	17.9	483	464	19.1
L.S.D. at .05	61	1.1	78	1.4	68	1.1	68	1.4	34		.62

20.2. However, these 2 varieties were higher in dry-matter content than Kennebec, with a mean of 18.7, Katahdin 17.3, and Irish Cobbler 18.7.

In the Maine tests in 1951 Green Mountain was somewhat higher than Merrimack in percentage solids, but in 1953 the reverse was true. However, the averages for the 8 tests showed 20.2 per cent solids for Merrimack and 20.1 for Green Mountain. Again these 2 varieties were almost alike in dry-matter content and again they were both higher, on the average, in this respect, than Kennebec or Katahdin (Tables 2 and 3).

In 1953, the tubers of a number of varieties grown in New Hampshire were made into chips. The potatoes were held at 40° F., transferred to 70°, then to 80° for 2 weeks, and finally chipped. The chips made from

Merrimack and Kennebec were rated excellent, and those from Katahdin good, but those from Green Mountain and Irish Cobbler were graded poor.

The tubers of Merrimack and a number of other varieties grown in Maine in 1953 were tested for chips and french fries. The potatoes were then stored at 45° F. for nearly 4 months. At the end of that time, a portion of each lot was continued at 45° and the remainder transferred to 60°. Chips and french fries were made from all lots, including those continued at 45°, 5, 11, 18, and 25 days after the transfer was made. On the basis of color and texture, good chips and french fries were made from the tubers of Merrimack held at a constant temperature of 45° F. for nearly 5 months. However, the chips and french fries made from the tubers transferred to 60° were on the average slightly superior to those from the tubers held constantly at 45°.

Merrimack is apparently immune from the common race of the late blight fungus. In a number of field tests and in at least one greenhouse test in which the plants were sprayed with late blight spores Merrimack failed to contract the disease under conditions in which Green Mountain and other susceptible varieties became infected 100 per cent. In several tests, the tubers of Merrimack were sprayed with blight spores and held in moist containers under conditions conducive to the development of tuber rot. No rot developed on the tubers of Merrimack provided they were not mechanically injured, but a high percentage of the tubers of Green Mountain and other susceptible varieties contracted the disease.

Merrimack seems to be somewhat resistant to early blight, caused by *Alternaria solani*. In 1952 at Salisbury, Maryland,[10] in tests of late-planted varieties early blight was present in early August and caused severe defoliation by the end of the season. Among the 14 varieties tested Merrimack and Sebago showed less injury than the others. Again in 1953 the incidence of early blight on the variety Merrimack was markedly less than on the other 17 varieties in the test.

Merrimack is highly field-resistant to, if not immune from, virus A. In 1948 it was grown in the field in hills alternate with hills of Green Mountain infected with mild mosaic. Healthy Green Mountains were planted at intervals throughout the field as checks. To supplement natural infestation with aphids, *Myzus persicae*, leaves from plants of Green Mountain harboring virus A and infested with aphids were dropped on plants of Merrimack early in August. During the last week in August the tops of the Green Mountain plants infected with mild mosaic were cut off to induce the aphids to leave these plants and infest the tops of the varieties being tested for resistance to virus A. As infection by virus A cannot be detected in the field during the first season after it takes place, one tuber per hill of each variety was harvested and taken to the Plant Industry Station at Beltsville, Maryland. Plants of Merrimack and of the Green Mountain controls were grown in the greenhouse during the winter of 1949. These plants were inarch grafted on plants of Green Mountain free from virus A. The plants of Merrimack were found to be free from virus A in contrast with the Green Mountain checks that were infected 100 per cent. The field-exposure test was repeated in 1951,

[10]We are indebted to James G. Kantzes and Carroll E. Cox, of the University of Maryland, for the information concerning the reaction of Merrimack to early blight.

with similar results. It is evident that Merrimack is highly resistant to, if not immune from, virus A infection by aphids in the field.

Merrimack is apparently highly resistant to net necrosis, a disease caused by current-season infection with the leaf roll virus. In 1951 Merrimack was exposed to leaf roll virus in the field. The tubers from these tests were stored at a temperature conducive to the development of net necrosis. One tuber of Merrimack out of 251, or 0.4 per cent, showed very mild discoloration of the flesh. In comparison, over 44 per cent of the tubers of the susceptible Green Mountain showed heavy discoloration. However, the tops of the Merrimack plants are susceptible to the leaf roll virus, but no more susceptible than those of its parent Saranac or of other varieties such as Green Mountain or Chippewa.

Merrimack is highly resistant to ring rot, as shown by tests in which the freshly cut seedpieces were dipped in a sludge containing the bacteria that incite ring rot. Merrimack did not become infected in tests in which the Katahdin check showed 90 per cent ring rot.

Discussion

Most potato varieties are limited in their range of adaptation. A variety may be superior to the commonly grown sorts in one State but not equal to the best variety in another. Merrimack is a variety of this type. It promises to replace some of the standard varieties in New Hampshire, but results so far indicate that in Maine it will not compete in yield with such varieties as Kennebec. However, in Maine, it yields highly enough so that certified seed could be produced profitably in that state to meet the demands that should develop in other sections.

Merrimack is similar to Kennebec in some characteristics. Although in comparative tests Merrimack did not yield so highly as Kennebec, nevertheless the former variety is capable of producing satisfactory yields of marketable potatoes with a high dry-matter content from which excellent chips and french fries can be made. Both varieties are highly resistant to, if not immune from, the common race of the late blight fungus, in both vines and tubers, field-immune from mild mosaic, and apparently highly resistant to net necrosis. Merrimack is superior to Kennebec in one important characteristic: it is highly resistant to ring rot. Merrimack is the first variety released that is highly resistant to both late blight and ring rot. Kennebec is highly resistant to late blight but susceptible to ring rot; Teton is resistant to ring rot but susceptible to late blight; and Merrimack is highly resistant to both diseases. The multiple-disease resistance found in Merrimack should make it valuable, especially to growers who find it difficult to control late blight and ring rot in standard varieties.

Merrimack is a late-maturing variety, and for best results in New England it should be planted as early as possible in the spring to allow time for it to develop to capacity and mature before the occurrence of killing frosts.

Summary

Merrimack is a variety of potato bred by the United States Department of Agriculture and tested in New Hampshire, Maine, and elsewhere as

part of the work of the National Potato-Breeding Program. Merrimack competed favorably with standard varieties in New Hampshire. It produced satisfactory yields of potatoes, with a relatively high dry-matter content from which excellent chips and french fries were made.

In the Maine tests it did not yield as well as some of the standard varieties but in tests it was found to be highly resistant to, if not immune from, the common race of the late blight fungus in both vines and tubers. It is moderately resistant also to early blight, and was apparently field-immune from virus A and highly resistant to net necrosis. Its vines are very susceptible to leaf roll virus. Merrimack is not only highly resistant to ring rot but is the first variety released that is highly resistant to both late blight and ring rot. Its multiple-disease resistance should make it valuable, especially to growers who find it difficult to control late blight and ring rot in standard varieties.

FORECASTING POTATO LATE BLIGHT IN MINNESOTA[1]

J. R. WALLIN[2], CARL J. EIDE[3] AND H. DAVID THURSTON[4]

Numerous methods have been proposed for predicting outbreaks of potato late blight caused by the fungus, *Phytophthora infestans* (1, 2, 3, 4, 5, 6, 9, 12, 13). Each method was based upon the assumption that the blight fungus would develop most rapidly within certain limits of temperature and rainfall, temperature and humidity, or temperature, dew, sky cover, and rainfall. These methods, discussed elsewhere (11), were derived from studies of meteorological data obtained over a wide range of climatic conditions representative of Great Britain, Europe and the Americas.

Recent investigations in Scotland and Germany illustrate the various weather conditions deemed essential for the appearance of *Phytophthora infestans*. In Scotland (7) late blight reportedly appears 15-22 days after a period of 48 hours or more of relative humidity greater than 75 per cent and temperature minima above 50°F. An instrument, the self-calculating blight forecast recorder, was developed for recording these periods. According to recent work in Germany (8), potato late blight should appear after a 33-hour period of temperatures between 55° and 64°F. and relative humidity 95 per cent or more with a maximum break of no more than 4.5 hours of relative humidity no lower than 82 per cent. The author indicated that control measures would be recommended after 2 such periods. However, no forecasts were made.

As a result of the establishment of the nation wide Crop Disease Forecasting Project in 1948 (10), considerable attention in the North Central States has been devoted to the epiphytology of late blight through cooperative work between the states. This involved studies of the relationship of the blight pathogen to weather conditions prevailing in an area of approximately 499,000 square miles. A method of forecasting late blight for the North Central States including Minnesota evolved from the weather-blight studies. The method, its objectives, accuracy, and future possibilities under Minnesota climatic conditions will be described herein.

[1]Accepted for publication September 10, 1954.
Report of an investigation conducted under the Research and Marketing Act (RMA Title II) in cooperation with the Minnesota Agricultural Experiment Station and the Iowa Agricultural Experiment Station. The authors wish to acknowledge the assistance of Dale N. Polhemus in tabulating the forecast data. The authors wish also to thank the following potato growers who cared for hygrothermograph stations during these studies: W. J. Koppen, East Grand Forks; Herman Skyberg, Fisher; John Bogestad, Donaldson; Ben Picha and Walter Turgeon, Oklee; Charles N. Bouton, Glyndon; and O. J. and Robert Odegard, Princeton, Minn. Similar assistance by Superintendent T. M. McCall and Bruce C. Beresford, Northwest School and Experiment Station, Crookston, Minn., is acknowledged with thanks.
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The Method

The method is based upon the findings that in blighted potatoes if concurrent temperatures were 75°F. or less, and relative humidities 90 per cent or more for at least 10 hours and the subsequent daily temperature maxima remained below 95°F., *Phytophthora infestans* sporulated and reinfected the host (15). The successful completion of secondary infection was determined by the increase in the number of lesions after such periods of 10 hours or more which were followed by temperature maxima below 95°F. These periods were determined from hygrothermographs located in potato fields. If one or more periods of 10 hours or more occurred within a 7-day period some blight development was predicted. Blight survival was considered possible despite the lack of a favorable period in seven or fourteen days if during the previous weeks there had been enough favorable periods for the establishment and development of the pathogen. The pathogen was assumed present in the seed. Therefore, from the time the shoots emerged, the extent of the pathogen's development was assumed to depend upon the weekly frequency and duration of the favorable periods.

In 1950, 1951, 1952, and 1953 hygrothermographs were located in potato fields in Minnesota. Charts from the instruments were received approximately every week. The number of favorable periods and daily temperature maxima were computed from these charts and projected into forecasts of the progress and state of development of the late blight pathogen.

Accuracy of Forecasts

Predictions of late blight development for certain areas in Minnesota have been made since 1950 when only one weather-blight station, Albert Lea, was operating. In the three forecasts issued for this area in 1950, *P. infestans* was predicted to persist and continue to develop if present and control measures were inadequate. Late blight was not reported from the Albert Lea-Hollandale area where rather rigorous spray schedules were maintained. However, 40 miles southwest of Albert Lea at Crystal Lake, Iowa, active moderate late blight infection was noted September 1. Erratic control practices allowed the pathogen to develop. In 1951, 7 forecasts were formulated from data obtained from 3 stations, *i. e.* Albert Lea, Crookston, and St. Paul. Blight developed as forecast in southern Minnesota (Albert Lea) and in the Red River Valley (Crookston) section.[5]

In 1952, 7 forecasts were issued again for Minnesota.[6] The data were obtained from weather-blight observation stations at Crookston, East Grand Forks, Fisher, Oklee, St. Paul, and Albert Lea. In all forecasts, vigilance for late blight was suggested for all locations. Unsprayed fields were predicted as danger spots. As predicted, late blight occurred in unsprayed fields. Moreover, many sprayed fields were blighted in the Albert Lea, St. Paul, Oklee, and Fisher areas. Furthermore, blight was found as predicted near Grand Forks, N. D. within a 25 mile radius of Fisher, Minn. where one hygrothermograph was located.

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[5]See U.S.D.A. Plant Disease Warning Letter No. 45. 1951.
[6]See U.S.D.A. Plant Disease Warning Letter of 1952.

The seven 1953 predictions were based upon data obtained from instruments and information obtained from seven stations: Albert Lea, East Grand Forks, Hollandale, Glyndon, Princeton, Oklee and St. Paul. The first forecast was issued June 28, 1953 about two weeks earlier than any previous year.

The following was issued on the above date:—"Northern Indiana, northern Iowa, southern Minnesota and eastern South Dakota have had sufficient favorable periods and temperature maxima to warrant careful observation for blight development. If incident in these areas the pathogen will be developing. We are expecting to find or to have a report within the next day or two that blight is developing in northern Iowa and southern Minnesota potato fields".

On July 1, three days after the forecast was issued, the late blight fungus was found sporulating on a cull pile near Hollandale which is 10-12 air miles northeast of the weather-blight post. On July 8 the disease was found in a field in the Hollandale area.

The forecast of July 14 indicated that the temperatures had been too high for further late blight development in southern Minnesota. Surveys to check this point were not made, but there were no reports of blight from the growers.

A prediction issued on July 28 again stated that in southern Minnesota and in adjoining states high temperatures and open foliage would reduce the possibility of spread during the ensuing two weeks. A hygrothermograph chart of week-ending July 19 from the Albert Lea station was the most recent at hand when the forecast was formulated. Furthermore, a survey of the area for small infection centers was suggested. This precaution was justified and was true of the Albert Lea area. However, at Hollandale blight development was greater than surmised as shown by a survey made on August 7, 10 days after the forecast was issued. On that date, late blight was found in every field examined near Hollandale, the severity ranging from light infection to almost complete defoliation. Growers reported that blight had been obvious for nearly two weeks, or since July 24. Apparently the time lag between the dispatch of the chart from the field to the return of the analyses to the blight observer allowed the status of blight development in a specific area to elude the forecaster. This situation was created by the delay in the receipt of charts from 19 locations. Obviously, a degree of accuracy was sacrificed in the interest of obtaining greater regional coverage.

The July 22 report pointed to Oklee in northwestern Minnesota as one of the most favorable centers for late blight in the region. Blight was reported at Oklee on July 29 and continued to develop despite a well-managed spray program.

In the forecast of August 11, all of Minnesota was declared favorable for late blight and local epiphytotics were predicted. At the time, the most recent hygrothermograph record at hand was that of week ending August 2. As indicated above, blight was epiphytotic at Hollandale August 7. Surveys made without the knowledge of the forecaster during August 8-10 revealed blight in six different localities within 50 miles of St. Paul in amounts ranging from a trace to moderate epiphytotics. On August 11-12 no blight was found in scattered fields between Grand Rapids and East

Grand Forks, except for that previously reported on July 29 at Oklee. A very intensive survey in the vicinity of East Grand Forks failed to reveal any blight there or southward in the Red River Valley except near Glyndon, where a trace was found. Another light infection was found near Detroit Lakes. Presumably, either the inoculum was scarce in the East Grand Forks area or the pathogen had not multiplied in sufficient quantity to become obvious.

On September 4 blight was again forecast for Minnesota generally and for the North Dakota section of the Red River Valley. By implication this excepted the Minnesota side of the river, which was justified in the East Grand Forks area, but not for the Barnesville-Baker-Sabin area where moderate epiphytotics were reported about August 20.

Two later reports were without specific forecasts for Minnesota. As a check on previous predictions it might be noted that blight was not reported in the East Grand Forks area at any time during the season.

Discussion

The results given above indicate that blight predictions can be made with considerable accuracy in areas surrounding the weather-blight observation posts. Accurate predictions were made for Hollandale on June 28, and for Oklee on July 28. Predictions for the state as a whole, issued August 11 and September 4, were also generally accurate. On the other hand the retarding effect of high temperatures on blight at Hollandale was probably over-emphasized in the report of July 28, and the locally unfavorable conditions at East Grand Forks should have had greater emphasis in the state-wide predictions.

Experience during the past 3 years, and especially in 1953, has indicated several ways in which the forecasting system can be improved, both as regards planning and the interpretation of results.

The most important need is for rapid dispatch of the hygrothermograph charts to the regional office for analyses. This should expedite the forecasting and allow the forecaster to keep abreast of the current field situation.

Another obvious need is for additional instruments to increase the number of weather-blight observation posts. The wide diversity in weather conditions that occur in this region would be sampled more adequately. For example, the hygrothermograph at East Grand Forks recorded 12 periods favorable for blight before August 9. At Oklee, about 55 miles east, there were 45 such periods during the same time. These conditions were reflected by the blight developments in the two areas.

The present interpretation of the hygrothermograph records is based primarily on the number of 10-hour or more "favorable" periods and their subsequent temperature maxima. Ten hours, however, is considered a minimum for sporulation and infection. If the period of favorable moisture and temperature conditions is longer, a larger amount of infection and more rapid development of the disease can be anticipated.

The importance of the length of the favorable period has been demonstrated by recent experiments made at the University of Minnesota. Potted plants inoculated with a freshly-made suspension of sporangia became infected in six hours, but not in four, when inoculated at 65°F.

The average number of infections per plant (determined by counting the spots on 6 leaves of each of six plants) increased if the time that the plants remained wet was lengthened. In one such experiment 11 lesions per plant were found after 6 hours incubation; 55 per plant after 8 hours, 100 after 10 hours, and 312 after 20 hours.

After the high temperature maxima of the 1953 season, the influence of so-called unfavorable daily temperature maxima on the development of the late blight pathogen will be studied more closely. Future forecasts will embody the results of this study. For example, during the 1953 season at Glyndon where late blight developed fairly extensively, there were 43 days of 80°F. or more, 21 days of 85°F. or over and 7 days of 90°F. or more during the 82-day period that records were taken. At St. Paul where late blight was epiphytotic temperature maxima were 80°F. or more on 28 days, 85°F. or more on 14 days, and 90°F. or more on 4 days over a 49-day period.

The forecast method will be revised as additional information is obtained. For example, a recent study (14) showed that spores of the blight fungus may be produced during the day under certain diurnal conditions. This finding illustrates that the true minimum conditions of time, temperature and relative humidity under which the fungus will persist in the field have yet to be established.

No claim is made that the method employed can be used to predict the date that late blight will become obvious. This depends upon the stage of plant development and the quantity of foliage canopy which should be determined by field observations. The fungus is assumed introduced with the seed at planting time and therefore to develop with the growing shoot if weather conditions are favorable. Local observers should verify blight incidence.

Meteorological factors will not account for the differences in blight development caused by fungicides and resistant varieties. Varieties like Cherokee and Kennebec remain free of blight until the appearance of the races to which they are susceptible, after which they can be considered as susceptible as the older varieties in predicting blight. However, varieties like Sebago, and to a lesser extent, Pontiac, although having no specific resistance to certain races of the late blight fungus, do have a certain amount of "field resistance" or "tolerance" to common strains of the blight pathogen, and under certain environmental conditions the disease will not spread as rapidly in these varieties as it will in Cobbler. Conversely, field observations indicate that the disease spreads even more rapidly in White Rose than it does in Cobbler. Where the variety is known, these facts can be taken into consideration in making predictions of the rate of spread.

Summary

Periods of 10 hours or more concurrent temperature $\leq 75°$ F. and relative humidity ≥ 90 per cent followed by temperature maxima $< 95°$ F. were used to predict potato late blight development. One favorable period a week was considered sufficient for limited reproduction and subsistence of the fungus in the foliage.

During 1950, 1951, 1952, and 1953, blight developed as forecast in those areas near the weather-blight observation posts.

The results thus far warrant continued efforts to forecast late blight on the basis of the same temperature and relative humidity relationships, with more consideration devoted to the influence of high temperature maxima immediately succeeding a period favoring secondary infection processes.

Because the early part of the record on each hygrothermograph chart is at least a week old when it reaches the forecaster any further delay in the receipt of these records decreases the practical value of the forecasts.

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THE TECHNOLOGY OF POTATO GRANULE MANUFACTURE[1]

R. L. Olson and W. O. Harrington[2]

Abstract

The production of potato granules, a dehydrated mashed potato product, is in line with a growing trend in the processing of foods toward concentration and improved convenience for use. Several methods for producing potato granules have been developed during the past 30 years. The only one of these methods currently in commercial use in this country is the "add-back" process. This process involves a recycling (adding back) of dried potato granules and mixing the recycled material with freshly mashed potatoes to form a friable moist mixture below 40 per cent moisture content. The moist mixture is held for a period during which moisture equilibration takes place and a reduction in starch solubility and swelling capacity occur. After drying under suitable conditions, the individual cells remain separated and substantially undamaged. Physical damage to the product may cause release of free soluble starch, which manifests itself as an undesirable rubberiness in the reconstituted product. Investigations have revealed relationships of several variables in the process to this specific attribute of quality and to others (*e.g.*, product yield and package density) and have provided useful information for process adjustment to improve the acceptability of potato granules.

Review of Previous Work

Preservation of potatoes by drying had its origin in South America pre-history, antedating by centuries the modern techniques of canning, freezing, and starch isolation. Through the past century much progress has been made in improvements in quality and convenience of preparation of dehydrated potato granules—a dehydrated product that appears to be destined for an important role in potato utilization.

Potato granules are pre-cooked, dehydrated potatoes produced in particulate form consisting substantially of whole tissue cells or small aggregates of cells. The product is characterized by a high degree of concentration (about 0.9 as dense as water) and great convenience of preparation (requiring only a simple mixing with hot liquid).

Potato granules differ from potato flour in that the tissue cells remain whole so that the cooked potato starch is constricted by the cell walls and does not form a homogeneous paste when rehydrated with hot water. Thus it is not possible to grind dried potatoes to produce granules. Such a process would produce potato flour, which forms a paste with hot water.

In essence, a process for production of potato granules consists of cooking, separating individual cells without rupture of cell walls, preventing

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reagglomeration of the separated cells, and drying. A number of processess have been reviewed by Olson and Harrington (19).

The first potato granule process was a spray-drying operation. Patented by Heimerdinger (15) and modified later by Bowen (4), Barker *et al.* (3), and Burton (6, 7), this method involved the spray drying of a slurry of cooked potatoes and water. An extensive commercial venture in spray drying of potatoes was described by Bowen (4). This operation was terminated before the start of World War II, although sales of product for restaurant and institutional use were reported as late as 1937 in *Food Industries* (10).

Later investigations by Barker *et al.* (3) and Burton (6, 7) indicated that the type of equipment used by Bowen was likely to have been responsible for considerable mechanical damage to the product. They suggested modifications that avoid the principal damaging operations but no commercial development of spray drying has followed.

In between these developments another approach to potato granule production was made. Bunimovitch and Faitelowitz (5) observed that if cooked potatoes are partially dried (to 40 to 60 per cent moisture content) it is possible to separate the tissue cells without undue damage to individual cells. From this observation has stemmed a number of processess that differ principally in the means of lowering moisture content of cooked potatoes to the 40 per cent level. Bunimovitch and Faitelowitz (5) accomplished the initial drying stage by direct dehydration of cooked cubes of potatoes. Granulation of the partially dried cooked cubes was accomplished by forcing them through a screen. This method is not completely satisfactory, because a considerable amount of damage is done to the product and furthermore, because of non-uniformity of drying an appreciable portion of the product is too dry to granulate properly.

Another development accomplished the initial drying step by direct drying on drum driers to about 40 per cent moisture level (Jones and Greer, 17 and 18). The partially dried material is reduced to a granular condition by passage through a hammer-mill.

A number of investigators seized upon the effect of freezing and thawing of cooked potatoes as an aid to removal of part of the moisture in potatoes (Willets and Rendle, 31, 32; Poulton and Noel, Ltd., and Bostock, 21; Rivoche, 26, 27, 28; Greene *et al.*, 11, 12, 13; and Hall, 14). It is possible after freezing and thawing of cooked potatoes to express enough sap from them to achieve a moisture content of 40 to 50 per cent by application of direct pressure or centrifugation. This method has had some commercial development in Europe and, for a short time, a plant using this process operated in Pennsylvania.

The other method that has been widely investigated for the reduction of moisture content of cooked potatoes to approximately 40 per cent is by addition of an appropriate amount of previously dried material. This is called the add-back process, and early developments of this method were described by Volpertas (29, 30), Rivoche (26, 27), Rendle (24, 25), and Bar (1).

There have been two other developments in the manufacture of potato granules that do not depend upon the initial first stage drying operation. In one of these methods cooked potatoes are mashed and cooled

for a sufficient period of time to improve the friability of the mash so that it is possible, by gentle extrusion, to granulate the product without undue cell rupture and subsequently dry it without reagglomeration of the separated cells (Barker, 2; Proctor and Sluder, 22, 23; Campbell *et al.*, 8).

The other method consists of extracting the moisture from cooked potatoes with a water-miscible organic solvent. In describing this method, Heisler *et al.* (16) indicated that ethanol is a relatively good solvent for this process, for reasons of efficiency of water extracted relative to amount of solvent required, distillation characteristics for solvent recovery, ease of removal of residual solvent from product, and effect of solvent on flavor of product.

At present the only significantly successful commercial process for potato granule manufacture in this country is the add-back method. Because of this fact, some of the details of this process will be elaborated in this paper.

It should be mentioned that a related, but not a granular, product has undergone trial sales for several years and may also have a position of importance. This is a dehydrated, pre-cooked mashed potato in the form of porous shreds that will reconstitute to mashed potatoes upon mixing with hot water.

In addition, experimental investigations are under way in several research institutions that may lead to further improvements in potato granule processes.

The Add-Back Process for Manufacture of Potato Granules

In the add-back process for potato granule manufacture, cooked potatoes are thoroughly mixed (primary- or mash-mix) with enough previously dried potatoes to produce a mixture with a moisture content of less than 40 per cent. The mixture is tempered by being allowed to stand and cool to room temperature within a 5 to 15 minute period. A short mixing operation (granulating mix) is used to reduce agglomerates. A 20 to 45 minute tempering period follows during which the mixture loses its tendency to be sticky or gummy, becoming friable. In this condition the mixture can be further subdivided into small aggregates and separate tissue cells by further gentle mixing action (fluffing mix). The granulated, moist mixture is then dried. Pneumatic driers are in most common use, although tray and other types of driers have also been used.

The dried product is screened generally into three fractions. The coarse material, which will not pass a 16- to 24-mesh screen, cannot be recycled in the process because it does not equilibrate rapidly enough in moisture content to be effective in the add-back step. This fraction will also contain all but a negligible amount of peel fragments that may be carried into the system with unpeeled or inadequately trimmed potatoes. The small-sized particles that will pass through a screen of 65 to 70 mesh include the fraction of the product which is packaged for sale. The intermediate-sized material and enough of the fine material to provide a continuous operation is recycled to the primary mixer.

Quality Attributes of Importance in the Add-Back Process for Potato Granule Manufacture

There are several criteria that are useful in describing the quality of potato granules and the process by which they are made. An important quality characteristic in the add-back process is the degree of granulation, which is reflected in the yield of fine-particle-sized material after screening. It is not merely necessary to have a sufficient yield of minus-70 to pack as finished product, but considerable excess is required to provide a high quality for recycling.

Another criterion of quality is the bulk density of the material that is packed as finished product. A high bulk density is desirable for military rationing as the greater concentration allows for lowered storage space and shipping requirement. In domestic markets the degree of concentration is less important but uniformity of product is very important because most users are familiar with volume measurement in food preparation. Bulk density must be uniform if a standard recipe is to be used.

The flavor, color, and texture are the important subjective criteria of quality that must always be considered in food product development. Flavor can be appraised only by organoleptic judgments. Color and texture may lend themselves to more objective measurements but values must be correlated ultimately with subjective appraisals. For much of the early developmental work on potato granules, texture appraisal was very essential because this quality attribute was frequently out of control and was markedly affected by many possible changes in the process.

Because it was desirable to discover the effects of minor changes in the potato-granule process, it was almost essential that an objective texture analysis be developed. The relationship of disrupted tissue cells, release of free soluble starch, and a rubbery or pasty texture of reconstituted potato granules was recognized. It was possible to measure the free starch in potato granules by chemical analysis of a selective extract of the starch from the cell surfaces and disrupted cells as a sample of potato granules was extracted in an excess of water at a controlled temperature. The intensity of blue color developed by iodine addition was measured photoelectrically and the quality thus measured has for convenience been designated the "blue value index."

Considerable deviation has been found between subjective appraisal of texture and the "blue value index" apparently depending on the raw material and processing method used. However, where raw material was the same and only minor deviations in processing method existed the "blue value index" has been found to give considerable help in identifying the effect of changes in processing variables on product quality.

Effect of Process Variables in the Add-Back Method of Potato Granule Manufacture

The recycling of large amounts of dried product, as required in the add-back method of potato granule manufacture, complicates the study of the process. The amount of solid material recycled in the moist mixture is about 85 per cent. On a batch-operated system 8 to 10 cycles must be completed to approximate a steady state of operation at which the full

effect of a change in the process may be measured. Even then the interactions of various factors in the process make cause and effect relationships difficult to interpret. However, it has been possible to control variables in such a way that the effect of certain operations can be established as a trend holding over a wide range of operations.

Thus, it has been ascertained (Olson *et al.*, 20) that with decreasing moisture in the moist mixture, package density and the degree of granulation increases, while the amount of free starch is decreased. With an increase in tempering time the degree of granulation increases; and with a decrease in temperature of drying air, the package density increases. Further investigations along this line (Cooley *et al.*, 9) demonstrated that free starch increases with increase in air velocity in a pneumatic drying system.

In continuation of these studies other investigations are in process on such variables as product temperature at different phases of the process, raw material variation, use of chemical additives to alter product quality, and others.

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NEWS AND REVIEWS

CALL FOR TITLES OF PAPERS

The next annual meeting of the Potato Association of America will be held September 5-9 at Michigan State College, East Lansing, Michigan. The meeting will be held under the auspices of the American Institute of Biological Sciences (A.I.B.S.).

Complete programs of all societies will be printed in the A.I.B.S. Bulletin. In order to do this, titles of papers to be presented must be in the hands of the secretary by May 20.

Please send titles of papers you plan to present, at the annual meeting, prior to May 20 to R. W. Hougas, Department of Genetics, University of Wisconsin, Madison, Wisconsin.

Joint sessions will be arranged with other societies if possible.

Your cooperation in meeting the deadline for titles will be greatly appreciated.

Please bring this notice to the attention of your students and colleagues.

R. W. Hougas
Secretary

CERTIFIED SEED POTATO CONTROL AREAS IN BRITISH COLUMBIA, CANADA[1]

H. S. MacLeod[2]

In Canada all the work of inspection and certification of seed potatoes is conducted by the National Government, and the rules, regulations and standards are made and administered by the Canada Department of Agriculture. Therefore, these are the same in all the seed-producing provinces in Canada. We believe that this tends to give much more uniformity of quality to our Canadian Certified and Foundation classes of seed potatoes produced in the various provinces of Canada than if each province had its own separate rules, regulations and standards, administered by different organizations. This applies to both the Certified and the Foundation classes of seed. However, the growers in any province of Canada, or in any part of any province, may do all they possibly can to exceed the requirements of our regulations and standards and produce Certified and Foundation seed of an exceptionally high quality.

If or when certified seed potato growers in British Columbia wish to adopt and comply with exceptionally strict rules, regulations and standards in order to facilitate the production of high quality seed, they may apply to the Lieutenant-Governor in Council for authorization to have their locality constituted as a "Certified Seed Potato Control Area." In each of three localities in British Columbia, Canada, certified seed

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[2] Officer-in-Charge, Seed Potato Certification, Plant Protection Division, Canada Department of Agriculture, Vancouver, B. C.

potato control areas were established several years ago and continue to be maintained as such. These areas are established and maintained under the authority of the Certified Seed Potato Act of British Columbia and regulations under that Act, passed by the Provincial Government, and apply to the three areas. The regulations under this Act are in addition to those under the Destructive Insect and Pest Act governing the production and sale of Canadian certified seed potatoes.

In order that the seed growers in any locality may obtain authorization to have that locality constituted as a "Certified Seed Potato Control Area," it is necessary that a large majority of the land-owners there desire to have that done. For instance, in the Province of British Columbia it is required by the Certified Seed Potato Act that any locality that applies for authorization to be constituted as a Certified Seed Potato Control Area must show by names on petition that at least 80 per cent of the land-owners within the locality desire to have that done. Otherwise, the application would not be accepted.

The petition from the growers requesting that their locality be constituted as a Certified Seed Potato Control Area shall:

(a) Contain a description of the proposed Area and its definite boundaries.

(b) State the variety or varieties of potatoes proposed to be produced in that area, and

(c) State the names of three persons whom the petitioners desire to be appointed as members of the Seed Control Committee of that Seed Potato Control Area, and who express in writing their willingness to act. These three members of the Committee are nominated by the growers in the locality, and there shall be a fourth member nominated by the Minister of Agriculture in the Province concerned. Duties of the Committee are to conduct the work concerning that Seed Control Area. In order to assist in conducting this work, the Committee has the power to appoint any necessary inspector. It has also authority to charge and collect such sums as it deems proper to meet its expenses in carrying out its work.

Some other very important requirements and regulations that govern Certified Seed Potato Control Areas are:

1. That there must be additional distance of isolation between the Certified Seed Potato Control Area and any other place where potatoes are being grown. Under our ordinary regulations governing the production of certified seed potatoes in Canada, the minimum distance required for isolation is 200 feet, but under the regulation that applies to Certified Seed Potato Control Areas in British Columbia the minimum distance required for isolation is one-half mile (that is, 2,640 feet). The regulation concerning this states that "the minimum distance required for the isolation of a seed potato crop within a Seed Potato Control Area from any crop of potatoes planted outside the Seed Potato Control Area shall be one-half mile." This is considered to be a great assistance in preventing the aphids from spreading virus diseases from the potato crops outside the Seed Potato Control Area to crops within that Area.

2. The control of the seed that is to be planted in any one Area and the varieties that shall be grown there. For instance, one of the regulations governing these Areas states: "No person shall plant any potato seed within a Seed Potato Control Area other than the Foundation class of the varieties Warba, Netted Gem, and White Rose, excepting in variety test plots conducted by the Seed Control Committee." Another regulation states that "All seed that is to be planted in the Seed Control Area must be obtained from a source and through channels recommended by the Seed Control Committee."

   This gives the assurance that no seed potatoes of an unknown origin nor of undesirable quality, nor any uncertified potatoes are planted in these Certified Seed Potato Control Areas. This is very important. It assists very much indeed in preventing the introduction of disease and other pests and impurities into the seed crops in these Seed Control Areas.

   The varieties of potatoes and the number of these that may be grown in any one Area are decided by the vote of growers in the Area concerned, with the approval of the Seed Control Committee for that Area, and with the approval of the Department of Agriculture within that Province. These varieties and the number of same may vary according to the desires and requirements of the growers, their Committee, and the Department.

3. Compulsory roguing from the crops in the Seed Potato Control Areas any and all plants that are, or may be, or are suspected to be affected by disease. Compulsory control, as much as possible, of all injurious insects. Regulation concerning this states that "All crops must be rogued and diseased plants destroyed and injurious insects controlled in accordance with instructions of the Seed Control Committee for the Area concerned, these instructions to be issued in notice form to any owner or occupier where such actions are deemed necessary by the Committee."
4. Proper disposal of potato crops that are not within the standards for the Seed Control Area is directed by a regulation that states: "The owner of any potatoes within the Seed Potato Control Area and which potatoes do not qualify for the standard of this Area shall make such disposal of them as the Committee may direct."
5. Thorough disinfecting of potato storage houses, machinery, *etc.*, is covered by regulation that states: "The owner of any warehouse, place of storage, vehicle or machine within the Seed Potato Control Area suspected of being infected with a readily transmissible potato disease shall disinfect the same at a time and place and in a manner as directed by the Committee."

Another regulation under the Certified Seed Potato Control Act states that "any owner or occupier within the Seed Potato Control Area failing to comply with the requirements of a notice given under this Section within the time given in the notice shall be guilty of an offense against these regulations and the Committee shall have authority to see that the instructions are carried out by any means it finds necessary, charging the guilty person with the cost."

The chief purposes of these Certified Seed Potato Control Areas, as outlined above, are to facilitate the production of high quality seed and to obtain on the markets the naturally resulting better demand and higher price for such seed, and also by using this higher quality seed to obtain a greater yield per acre and thus assist in reducing the cost of production and thus increasing the net profit to the growers. These objectives are certainly very much worthwhile. It is very pleasing to note that where these Certified Seed Potato Control Areas are well established and properly maintained, the results obtained are excellent as a means of improving the quality of the seed.

USDA ISSUES IMPORT kEGULATIONS FOR IRISH POTATOES

Regulations specifying minimum grade and size requirements of Irish potatoes imported into the United States were recently issued by the U. S. Department of Agriculture.

The regulations, which became effective on February 7, 1955, limit the importation of potatoes of the round white or red skin varieties, when in packs of 100 pounds or more, to U. S. No. 1, or better grade, 2 inches minimum diameter. Imported potatoes of the round white or red skin varieties, in packs of less than 100 pounds, must meet the requirements of the U. S. No. 1, size A, 2 inches minimum diameter. Long white varieties, such as the Russet Burbank variety, must meet the requirements of U. S. No. 2, or better, grade, Size A, 2 inches minimum diameter or 4 ounces minimum weight. The regulations do not apply to imports of certified seed potatoes.

The regulations also designate the Canadian Fruit and Vegetable Inspection Services as an authorized inspection agency and provide that the Canadian potato standards may be used on the same basis as comparable United States grade standards.

The controls imposed by the regulations are required by a recent amendment, Section 608e, to the Agricultural Marketing Agreement Act of 1937.

NEMATOLOGY WORKSHOP HELD AT LONG ISLAND, NEW YORK FEBRUARY 14-25

A Nematology Workshop was held at the United States Department of Agriculture's Golden Nematode Control Headquarters in Hicksville, Long Island, New York, February 14-25, 1955 under the direction of Mr. Joseph F. Spears, Project Leader. This training course dealing with plant parasitic nematodes was sponsored by the Nematode Control Project of the Plant Pest Control Branch, Agricultural Research Service, and brought together some 40 Federal and State employees in the New York area concerned with nematode regulatory problems.

The principal subject matter covered in this training course included laboratory techniques used in the preparation of microscopic mounts and the means of isolating nematodes from bulbs, plant tissue and soil. These studies included anatomy, morphology and life cycles and considerable time was devoted to nematode systematics. However, since the personnel who attended this course were employees directly concerned with nematode regulatory problems, particular emphasis was placed on those groups of

nematodes with species which have received special surveys or attention from a regulatory viewpoint. Extra time was taken to study the genus *Heterodera* with such important species as *rostochiensis, tabacum, schachtii,* and *glycines.* Another laboratory exercise familiarized employees with the genus *Ditylenchus* containing the important species *destructor* and *dipsaci.* A full period was used to acquaint personnel with the nematode *Radopholus similis,* a potential threat to the citrus industry. Additional time was allotted to either known or suspected agricultural pests such as species of *Meloidogyne, Belonolaimus, Trichodorus, Tylenchorhynchus, Pratylenchus* and *Xiphinema.*

Instructors for the course were: Mr. A. L. Taylor, Section of Nematology of the U. S. Department of Agriculture, and Dr. J. N. Sasser, North Carolina State College. They were assisted by Dr. Victor Dropkin, Mr. George Fassuliotis of the Nematology Section and Mr. Daniel D. Betz, Golden Nematode Control Project. Many of the personnel attending the course were directly concerned with potato problems, therefore, eight hours of instructions were set aside for lectures and demonstrations concerning the principal varieties of potatoes and the diseases and insects that affect them. This phase of the instruction was under the direction of Cornell University instructors: Dr. Robert Dickey, Dr. Richard Sawyer and Dr. Maurie Semel.

POTATO RESEARCH ADVISORY COMMITTEE HOLDS FIELD MEETING IN FLORIDA

The Potato Research and Marketing Advisory Committee this year combined inspection of harvesting and packing methods and a tour of research activities of experiment stations with its review of Department of Agriculture potato research. The committee met February 28 to March 3 in Florida.

On March 1, committee members observed harvesting and packing house operations and inspected the field plots and trials of fungicides, insecticides, fertilizers, and seed varieties at the Subtropical Experiment Station (branch of University of Florida) in the East Glades section near Homestead, Florida. On March 3 they observed potato production in the Tocoi, Elkton and Federal Point areas and inspected the facilities and field plots of the Hastings Potato Laboratory near Hastings, Florida. They then toured the University campus and Experiment Station farms at Gainesville.

February 28 and March 2 at Miami the committee reviewed potato research programs of the Department of Agriculture. Its principal recommendations were:

Production Research—To expand (1) work on the evaluation of the potato introductions of the Inter-Regional Potato Introduction Station at Sturgeon Bay, Wisconsin, by providing services of a cytogeneticist and a pathologist to determine more quickly the breeding behavior and characters and disease resistant qualities of the introductions from all parts of the world for use by all potato breeders, and (2) work on diseases and the genetics and breeding of commercially superior varieties having better eating quality and multiple resistance to diseases and insects.

Utilization Research—To expand research (1) and (a) improvement of quality of potato chips, (b) improvement of potato product quality, stability, and convenience of preparation for the table, (c) preparation of potato flakes on single drum dryers with emphasis on development of a flake capable of reconstitution under a wide variety of conditions and from potatoes of lower solids content than used at present, (d) development of new potato products, and (e) improvement of processing methods and reduction of costs with particular reference to production of dehydrated potatoes for use in expanding civilian markets in such products as canned hash and stew and dried soup mixes; and (2) fundamental work on the composition of potatoes, as a basis for controlling undesirable changes during processing and for attaining maximum quality and stability of processed potato products.

Marketing Research—To expand (1) work on the development and evaluation of improved structures, plant layout, work methods, and equipment for handling, storing, and shipping potatoes; and (2) basic studies on the post-harvest physiology of potatoes.

The committee recommended that the Department expand its service work to (1) expand agricultural estimates to segregate the summer crop in the remainder of the late States and (2) resume the February 1 and March 1 merchantable stock reports and add a December 1 merchantable stock report.

The committee said that State departments of agriculture should expand their service work to (1) improve and maintain the quality of potatoes through development and adoption of better harvesting, grading, packing, and handling practices; (2) widen market outlets and move seasonal surpluses; (3) collect and disseminate basic data and local and nearby market information: and (4) improve existing facilities, and design and locate new facilities for assembling, handling, and processing potatoes.

The committee also recommended expansion by the cooperative extension service of its educational work.

Committee members attending the meeting were Edward H. Anderson, Edward H. Anderson & Co., Chicago, Ill.; Henry W. Bibus, Jr., Chesterfield, N. J.; Claude E. Botkin, Claude Botkin Farms, Arvin, Cal.; J. Abney Cox, H. L. Cox & Sons, Princeton, Fla.; Harold J. Evans, New York Cooperative Seed Potato Association, Incorporated, Georgetown, N. Y.; Frank W. Hussey, Maine Potato Growers, Inc., Presque Isle, Me.; R. W. Kohler, American Stores Co., Philadelphia, Pa.; Dr. James E. Kraus, University of Idaho, Moscow, Idaho; Frederick J. Meyer, Red Dot Foods, Inc., Madison, Wis.; Ben Picha, Grand Forks, N. D.; and L. E. Waters, Colorado Potato Growers Exchange, Denver, Colo. Roy Magruder of the Agricultural Research Service is executive secretary of the committee.

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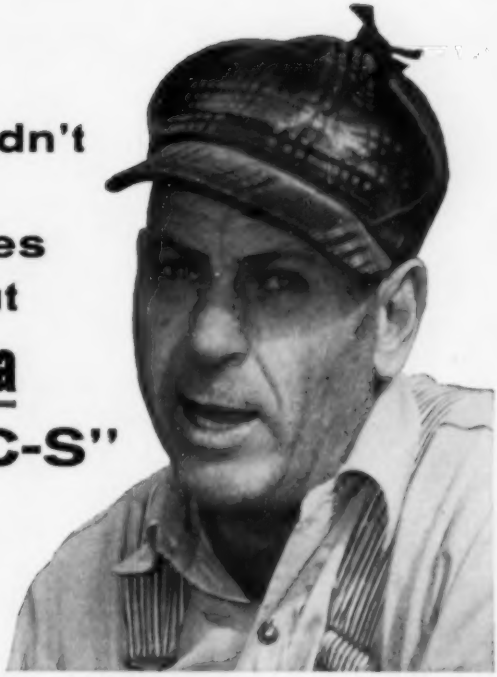

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